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TEACHING MACHINE STUDY. FINAL REPORT.

EVCO, ALBUQUERQUE, N.M.

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IN AN INVESTIGATION OF THE POTENTIAL OF TEACHING MACHINES IN THE JOB CORPS MATHEMATICS PROGRAM, EXISTING JOB CORPS ARITHMETIC MATERIAL WAS PREPARED FOR INSTRUCTION BY MACHINE AND PROGRAMED TEXT, AND THEN FIELD TESTED. REVISIONS WERE MADE, AND A PROGRAMED MANUAL FOR INSTRUCTORS WRITTEN, AFTER WHICH A NEW FIELD TEST WAS RUN. IN THE INITIAL FIELD TEST, THE TEACHING MACHINES WERE GREATLY PREFERRED TO THE PROGRAMED TEXT AND SHOWED SLIGHTLY HIGHER ACHIEVEMENT GAINS. IMPROVEMENTS PRECEDING THE SECOND FIELD TEST INCLUDED A REVISION OF THE TEXT, IMPROVEMENT OF THE ADMINISTRATIVE ASPECTS OF THE SYSTEM, ADDITION OF REMEDIAL TUTORING, AND DEVELOPMENT OF A NEW TYPE OF STUDENT RESPONSE FORMAT FOR PROGRAMED TEXTS. THIS NEW FORMAT GAVE IMMEDIATE PEEK-PROOF STUDENT FEEDBACK, IMMEDIATE DIAGNOSTIC FEEDBACK TO THE INSTRUCTOR, AND COULD BE USED DIRECTLY AS INPUT DATA FOR ITEM-ANALYSIS. THE SECOND FIELD TEST SHOWED THE LEARNER-ORIENTED PROGRAMED TEXT TO BE MORE EFFECTIVE THAN THE TEACHING MACHINES AVAILABLE. NO COMPELLING DATA SUGGESTED THE WIDE-SPREAD ADOPTION OF THESE MACHINES IN CONSERVATION CENTERS. APPENDICES INCLUDE DATA FROM PHASES II AND IV AND CORRELATION DATA. (BB)

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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FINAL REPORT

CONTRACT No. 1280

TEACHING MACHINE STUDY

EM 006 662

Submitted by: **EVCO**

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NOTE

The portion of the study performed in each phase is as follows:

Phase I	Preparation of existing Job Corps arithmetic material for use in the MTM (Mast Teaching Machines) machine and in the 576-65 DuKane machine.
Phase II	Field testing of the machines and materials on an operating Job Corps site and submission of an interim report to the Job Corps.
Phase III	Preparation of a programed manual for instructors on how to set up and administer machine-mediated programed instruction.
Phase IV	Field testing of the programed administration manual, machines, and materials on a second operating Job Corps site.
Phase V	Preparation of a final report of findings of the study and recommendations for further efforts in this area.

FINAL REPORT

CONTRACT NO. OEO-1290

TEACHING MACHINE STUDY

This constitutes the final report on Contract No. OEO-1290, "An Investigation of the Potential Contribution of Teaching Machines in the Job Corps Mathematics Program" — Submitted January 13, 1967.

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I. INTRODUCTION: SUMMARY OF PHASE II AND PHASE IV EXPERIMENTS

A. Phase II testing conducted at Grants compared the effectiveness of instruction with two different teaching machines, and with a programed textbook format similar to that now in use in the basic mathematics curriculum in the Conservation Centers. A novel experimental design was used in the study to enable us to use each student as "his own control group." Basically, this involved rotating each student on different schedules, so that upon completion of each unit of instruction he would change to a different mode for the next unit. (For example, Unit 1 on one type of machine, Unit 2 on the programed text, Unit 3 on the other machine, etc.)

Since there was a very slight achievement differential in favor of one of the machines, and since the Corpsmen exhibited a strong preference for using this machine, we decided to drop the other machine from the experimental design for Phase IV testing. (The machine retained was the Mast; the machine dropped was the DuKane.)

B. Two major changes in the administration of the teaching machine study in Phase IV were:

1. Improvements in the administrative aspects of the system.
2. The addition of remedial tutoring activities to the overall system.

Whereas in Phase II the EVCO staff limited itself to conducting the study and relied on the course content itself to teach the subject matter, in Phase IV the EVCO staff was able to take advantage of the diagnostic aspects of the instructional system to identify and provide needed corrective teaching. The following paragraphs identify the fixed and dependent variables in the Phase IV study.

a. Mast Mode This was the only factor held more or less constant between Phase II and Phase IV. The content and presentation techniques were not changed, so this mode provides a relatively good data reference line between the two phases of the study. Given similar entry behaviors in the group of Corpsmen taking the course in this mode in both Phase II and Phase IV, any change in achievement should be attributable to the two aforementioned factors, i. e., improved administrative materials and the addition of tutoring activities.

b. Text Mode The text mode introduced two more variables as follows:

1) Based on what was learned during Phase II, an extensive revision of course content and instructional technique was accomplished. Among other things, Units 1 and 15 were divided into two parts, and virtually all units were rewritten in one degree or another.

2) Perhaps more significantly, the copying (or cheating) behavior was effectively extinguished by carefully instructing the six Corpsmen on this mode to cover the encoded responses at the bottom of each page with their time card, and not to look at them until they had written their response in the frame.

c. Text-and-Card Mode In order to provide a "controlled response" programed textbook, an adaptation of a recently-developed instructional technique was incorporated into the study. Basically, this involves printing a version of the Programed Textbook with no confirmations. Accompanying each Unit booklet were from two to eight pre-printed IBM-type cards with an answer displayed on them that might or might not be correct. We then asked the students to erase a block of conductive ink in the column marked "YES" if they thought the answer was correct as shown, or a block of conductive ink in another column labeled "NO" if they thought the answer displayed was incorrect. Depending upon whether the student erased the right block or not, he would find a "t" if his answer was correct, or a code number without a "t" if his answer was incorrect. He would then refer to an answer sheet to verify what the correct answer should have been.

This card accomplishes at least three things:

1) It provides a "cheat-proof" learning experience.
2) It serves as a highly effective diagnostic tool, since the instructor checks each card as it is completed and is thus able to pinpoint any difficulties the student might be having in concepts and/or computations.

3) It enables an item-analysis to be run with comparative ease, since the card itself can be used directly as computer input. Even without using a computer, we performed an item analysis of the card-mode group in approximately 1/5 the time required on a per-student basis in Phase II.

II. DISCUSSION

A. The Original Experimental Design The experiment was originally designed to investigate the potential contribution of teaching machines in the Job Corps Mathematics curriculum. Since the machines under study were of the "mechanical page-turner" type, they of course did not provide differential feedback based on the students' responses. Therefore, any hypothesized contribution would be in the areas of motivation or control.

The motivational aspects were investigated primarily in Phase II, where the Corpsmen rotated between the two machines and the programed textbook mode. Apparently there was a motivational effect of considerable strength, since the student attitude questionnaire indicated that the Corpsmen preferred the machines over the programed text by nearly nine to one (26 to 3).

Regarding control, neither machine used in Phase II turned out to be entirely "cheat-proof." It was easier for the Corpsmen to figure out how to copy answers on the DuKane machine than on the Mast, since the DuKane is provided with a knob that permits frame reversal. But the Mast also turned out to be something less than cheat-proof, since some of the Corpsmen in both Phase II and Phase IV rapidly learned that there was no effective control on "copying behavior." That is, they learned that they could operate the machine to expose the confirmation (answer) before committing themselves to a response on the paper answer tape.

In Phase II, the Corpsmen who worked on the mixed-mode (rotating from both machines to the text) scored somewhat better on both the unit tests and the Stanford Achievement Tests administered at the end of the study than did a "control group" of six Corpsmen who went through the program using the text-only mode.

B. The Modified Experimental Design For Phase IV of the experiment, we eliminated the DuKane machine, primarily because there was no significant difference in time or gain between the machines, the DuKane malfunctioned more frequently than the Mast, and the Corpsmen exhibited a 2-to-1 preference for the Mast. Since we had already elicited student attitude information and Unit Test performance data in the "each student his own control" design of Phase II, there was no need to continue this design in Phase IV. Alternatively we chose to set up a more-or-less standard control-group experiment, as follows:

We made a random three-way split of the 18 Corpsmen provided for the study. One group served as a "control group" to relate the results of Phase II and Phase IV by working exclusively on the Mast machine. (Their data then served as a kind of standard data-reference between the two phases.) The other two groups worked on the programed textbook, one using the same format utilized in Phase II, and the other using the "controlled response" version of the programed textbook described in Section I, paragraph B, 2.

NOTE: Since it had been determined that the machine did not provide a "cheat-proof" controlled response, we decided to adapt recently developed techniques for eliciting student responses before making confirmations available, in order to include a cheat-proof programed textbook mode in the Phase IV study. — It would not require too large a stretch of our definitions to characterize this technique as a simulated teaching machine.

Another change in Phase IV was the acquisition of more meaningful data on Corpsmen performance on the Stanford Achievement Tests. In Phase II we were able to retrieve only pre-experiment Stanford scores from six months before the study (i.e., May of 1966). In Phase IV we were careful to ensure that Stanford Achievement Tests were administered during the week immediately preceding the study, and again during the week after the study. Thus, we were able to "range in" on achievement gains related to the study itself with much more precision than we were able to in Phase II. (Advanced Form X was used pre-study; Advanced Form Y was used post-study.)

The final major change in the administration of the Phase IV experiment involved investigating the correlation of completion of the Word Problems program with reading achievement. To accomplish this we utilized a simple five-minute reading quiz administered immediately before and immediately after the study. In Phase II we had used this quiz just once during the experiment to provide a cross-check on the reported Job Corps reading level of the Corpsmen. This aspect of the study is discussed further in Section III, paragraph C, of this report.

III. RESULTS

A. Summary of Conclusions and Recommendations from Phase II and Phase IV

The following conclusions and recommendations are reprinted from the earlier Phase II and Phase IV reports.

● Conclusions from the Phase II Study

1. The Arithmetic Word Problems course produced substantial gains on the Stanford Achievement Test, Arithmetic Application Unit (Test No. 6 on Advanced Form Y).
2. The Stanford Achievement Test gains are appreciably reduced when the students take the course using only the programed textbook mode and not the machines.
3. Students using a textbook complete the course faster by 24 percent to 41 percent—but with a consequent achievement reduction of 34 percent based on the unit pre- and post-tests.
4. The Arithmetic Word Problems course can be easily administered at a ratio of about 1 staff member to 20 Corpsmen.
5. Corpsmen utilized in the study exhibited a strong preference for the machine over the programed textbook (about 9 to 1).
6. Corpsmen preferred the Mast machine to the DuKane machine (over 2 to 1).
7. When using the programed textbook the Corpsmen were observed routinely checking their answers at the bottom of the page before writing their answers in the book (a fact that they themselves also reported). It is a reasonable assumption that this accounts for both the time decrease and the achievement decrease on the text mode. This behavior, for all practical purposes, resulted in the Corpsmen taking a course of programed instruction consisting of 1182 copy frames.

8. The conclusion reported in Item 7 on the preceding page has serious implications for the programed-instructional materials now in use in the Job Corps. It is reasonable to conclude that if these materials were made cheat-proof, they would be markedly more effective. (See Item 3 on the preceding page.)

● Conclusions from the Phase IV Study

1. The instructional system described herein, and as now constituted, is a satisfactory model for an easily-administered, learner-oriented, self-instructional system. (On the sixth day, the Center staff ran it with no EVCO staff participation.)
2. The system produces significant achievement gains.
3. The largest gains (more than double the average) are produced in the text-and-card mode.
4. The Corpsmen like it. This was evidenced by the attitude surveys and was noted from their attendance record. During the second week many voluntarily came for both the afternoon and morning sessions in order to stay even and/or catch up. Also, they told their buddies about it, and at least two of them asked whether they could take the program also.
5. Posting scores on a daily basis creates a relatively powerful motivator.
6. A measurable improvement in reading ability is developed as a by-product, and is significant at the $\rho = .02$ level.

● Recommendations from the Phase IV Study

1. Perhaps the highest priority recommendation is to disseminate to the Conservation Centers the importance of instructing the Corpsmen to cover the encoded responses on the existing Mathematics system materials with a sheet of paper until they have committed themselves to a written response.

2. Further research should be performed on a more effective programed textbook format; for example, the text-and-card system described herein. We feel that the idea of an IBM-type card that provides immediate feedback to the student, immediate feedback to the instructor for diagnostic purposes, and can be used as input data to generate item-analysis feedback virtually overnight has considerable merit.

3. For any courses of a more advanced nature than the existing Mathematics and Reading systems, we recommend consideration of a programed notebook for the Corpsmen to retain for reference and review. We anticipate development of such a notebook for the Word Problems course, particularly to handle the units on geometry and linear algebra.

4. We recommend posting achievement scores in a highly visible location in the education rooms for its motivational effect. We do not recommend posting pre-test scores or gain since in Phase IV at least one Corpsman was observed purposely missing test questions on the pre-test so that he could get the best gain on each unit for all his friends to see. In future experimentation we expect to administer all unit pre-tests at one sitting, probably making them timed tests of no more than five minutes duration each to minimize test-fatigue. We will post only post-test results, and keep gain information to ourselves.

5. In the administration of a course such as Word Problems, we recommend scheduling only one unit per four-hour period. In other words, one unit per day, if on half-day education weeks, or two units per day if on full-day education weeks. If a Corpsman literally begs to do another unit, let him do it, but be sure that he has at least a full 1 1/2 hours available before quitting time (noon or five o'clock). In no case let him take the post-test unless he has at least 15 minutes to complete it before noon or 5 o'clock. (It is likely that a good many of the low gains and/or losses shown on post-tests during the Phase IV study were a result of starting the test at two or three minutes before noon or 5 o'clock.)

For Corpsmen finishing a unit and still having time on their hands before the end of the study period, enrichment material should be provided. In the Word Problems course, for example, using the Webster Publishing Company material, the Unit MEM-03 could follow Unit I of the program. A suggested correlation of MEM units to Word Problems units is tabulated below:

Unit 1	MEM-03
Units 2, 3, 4, 5	MEM-11
Unit 6	MEM-02
Unit 15	MEM-05
Unit 16	MEM-10
Unit 18	MEM-09

In addition, MEM-06 could be used as further enrichment for some Corpsmen.

FIGURE 1. STANFORD ACHIEVEMENT TEST DATA
(Plus Reading-Level Data)

NAME	JOB CORPS READING LEVEL	EVCO-TEST READING LEVEL		LAST SCHOOL GRADE COMPLETED	SPREAD BETWEEN Col 2a & 3	STANFORD ACHIEVEMENT TEST - SCORE ON APPLICATIONS UNIT		STANFORD GAIN (5b - 5a)
		Pre-X	Post-X			Pre-X	Post-X	
	Col 1	Col 2a	Col 2b	Col 3	Col 4	Col 5a	Col 5b	Col 6
GROUP A (Machine)								
1. CLAY	6	X	X	X	X	X	X	X
2. CRAVEN	IVa*	9	12	10	-1	6.7	6.7	-0-
3. GUARDIOLA	8	3	5	7	-4	6.3	7.4	+1.1
4. MENDOZA	8	2	5	9	-7	6.3	7.7	+1.4
5. ESTORGA	5	8	7	8	0	5.8	5.3	-.5
6. WILLIAMS	8	6	6	10	-4	4.4	5.3	+.9
	7.5	5.6	7.0	8.8	-3.2	5.90	6.48	+.58
GROUP B (Text)								
7. DAMPIER	7	4	4	9	-5	5.3	7.7	+2.4
8. DIETZ	6	7	5	7	0	5.8	7.7	+1.9
9. HEYMAN	8	7	12	10	-3	6.7	9.1	+2.4
10. LOPEZ	IVa*	12	12	7	+5	8.2	7.4	-.8
11. PALMER	IVa*	9	6	9	0	4.9	4.7	-.2
12. ROMAN	6	7	6	10	-3	5.8	7.9	+2.1
	7.8	7.7	7.5	8.7	-1	6.12	7.42	+1.30
GROUP C (Text-Card)								
13. SINGLETERRY	6	5	5	8	-3	4.4	7.9	+3.5
14. HENRY	IVa+*	4	7	12	-8	5.8	4.7	-1.1****
15. HERNANDEZ	5	3	6	9	-6	7.2	7.9	+.7
16. HUBBARD	6	4	5	10	-6	4.9	7.7	+2.8***
17. IKERD	5	X	X	X	X	X	X	X
18. GONZALES	8	5	9	7	-2	4.6	7.7	+3.1
	6.7	4.2	6.4	9.2	-5	5.38	7.18	1.80
Overall Averages	7.33	5.94**	7.00	8.88	-2.94	5.82	7.05	1.23

* A numerical value of 10 was assumed for averaging purposes.

** Compared to 6.1 average on Phase II experimental group.

*** Took SAT's before completing Unit 15-II, 16, 17, and 18.

**** See NOTE on page 13.

B. Updating of Phase IV Report Based on New Data Four of the Corpsmen involved in the Phase IV study left for the Christmas holidays without having taken the post-experiment Stanford Achievement Test. We obtained this data on January 10th, and it is now included in Figure 1.

Also, it should be noted that the pre-experiment Stanford test for student No. 2 was retrieved from the Center files, and re-scored by the EVCO staff. As hypothesized, this data had in fact been spurious, and when re-scored indicated a grade level of 6.7 on Stanford Applications rather than the 11.1 previously reported. The effect of this was to show a zero-gain, rather than the earlier-reported 4.4 loss.

NOTE: We were tempted to exclude Corpsman No. 14 from the data, since he scored very low and very erratically on the SAT tests, as follows:

	COMPUTATIONS	CONCEPTS	APPLICATIONS
PRE	2.6	5.7	5.8
POST	3.6	3.6	4.7

Note that although he only got a 2.6 in Computations on the pre-test, he managed to get a 5.8 on Applications.

Then, on the post-test, although he improved on Computations to 3.6, he dropped to 4.7 on Applications.

Incidentally, this is a high school graduate from a New Orleans high school built for 1400 students which currently has an enrollment of 2700. Also, he had been on a work detail all night before the post-test and was routed out of bed to take it.

If the data were re-run without his scores, the text-card group would have averaged a score of 7.80 on the Stanford Application Unit for an average gain of 2.52.

Figure 2. Expected Entry Level

vs.

Actual Entry Level

	PRE-STUDY		POST-STUDY	
SAT Computation *				
Phase II (Grants)	3 for 31	10%		
Phase IV (Mexican Springs)	2 for 20	10%	8 for 20	40%
	5 for 51	10%		
Reading **				
Phase II (Grants)	26 for 35	75%		
Phase IV (Mexican Springs)	11 for 18	61%	15 for 16	94%
	37 for 53	70%		

* The expected mathematics level was the 7th grade level, since the Corpsmen had all completed the mathematics curriculum, and should have been at approximately the 7th grade level (PM 400). EVCO used a score of 7.0 or better on SAT Computations as an independent test to see if Corpsmen were indeed at or above the 7th grade level.

** The expected reading level was a Job Corps Reading Level of 5, approximating a 5.5 school grade level. EVCO used the Ohio Literacy Test, which gives grade level equivalence, as an independent test to find if Corpsmen were indeed at or above the 5th grade reading level.

C. Discrepencies Between Mathematics and Reading Entry Levels Expected and Actual Entry Levels The entry level skills specified for the Corpsmen participating in the study at both Grants and Mexican Springs were:

1. A Job Corps Reading Level of 5 or above, and
2. Completion of the Mathematics system through Decimals (MDT).

Because we administered the EVCO Reading Quiz as a cross-check on Job Corps Reading Level, we were able to analyze accurately how many of the Corpsmen actually had the required entry behavior.

Also, administration of the Stanford Achievement Test permitted us to assess accurately what percentage of the Corpsmen possessed the terminal behavior associated with successful completion of the Mathematics system in the Center.

The results are as follows:

1. Reading

   We requested for the study Corpsmen with a Job Corps reading level of 5, which approximates a 5.5 school grade level. The criterion that we used to check the reading achievement level was a fifth grade equivalency. When we applied this measure, we found that 70 percent of the Corpsmen involved in the study had the expected entry behavior. See Figure 2 for additional detail.

2. Mathematics

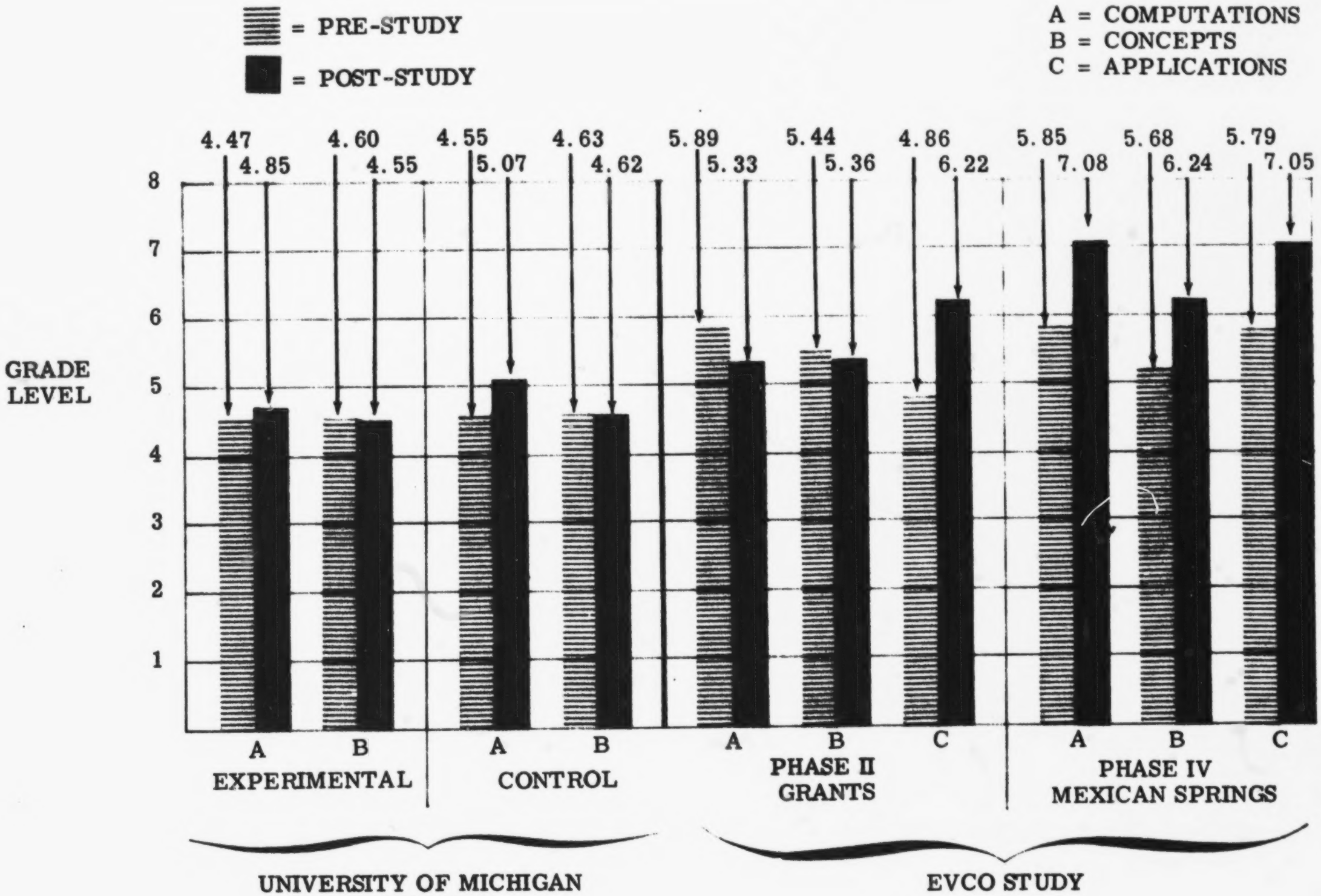
   The Job Corps Mathematics Systems Manual (PM 400) indicates that completion of the existing Mathematics curriculum should produce approximately a seventh grade achievement level. Accordingly, we selected a score of 7.0 or better on the Computations unit of the Stanford Achievement Test as our criterion level.

When we applied this measure to the control group at Grants (we used the control group since they were the only ones on whom we had valid Stanford tests at the time of the experiment), and to the 20 Corpsmen on whom we had entry data at Mexican Springs, we found that only 10 percent of all the Corpsmen selected for this study had the expected mathematics achievement level. (See Figure 2.)

AS A BROAD GENERALIZATION, IT SEEMS REASONABLE TO SUGGEST THAT THE READING SYSTEM IN THE JOB CORPS IS WORKING MUCH BETTER THAN THE MATHEMATICS SYSTEM. THIS WILL BE DISCUSSED IN MORE DETAIL IN SECTION IV, PARAGRAPH A.

FIGURE 3

PERFORMANCE ON STANFORD ACHIEVEMENT TESTS IN TWO SEPARATE STUDIES AT THREE JOB CORPS CENTERS



D. Comparison of Overall Results of this Research and Previous Similar Research As part of an earlier evaluation of the Job Corps Mathematics curriculum, some data has been obtained on mathematics achievement levels expected of Corpsmen upon completion of the existing Mathematics program. The final report on Contract No. 953, "Evaluation of Mathematics Curricula," dated July 14, 1966, contains data that enabled us to construct the bar chart shown on the facing page (Figure 3). The experimental group shown in the data for Contract No. 953 was using an experimental mathematics system titled "Programed Math for Adults." The control group used the existing Job Corps Mathematics system.

The following observations can be made:

1. In a test of the existing Mathematics system and an experimental alternative system, the entry level of all the Corpsmen in the study, based on the Stanford Achievement Test Computation and Concepts units, was around the middle of the fourth grade.
2. Upon completion of both the existing and experimental systems, some gains were noted (slightly higher for the existing system) but nowhere near the expected level of seventh grade. Only the control group got slightly above the fifth grade level on the Computations unit.
3. In the research being reported here, conducted approximately a year later at two different centers, Corpsmen who had completed the Mathematics curriculum—and who were expected to have a mathematics achievement level of approximately seventh grade—in fact were at levels in the mid-fifth grade range. (This improvement could be accounted for by a general maturing of the system, or by smarter Corpsmen, better trained staff, more post-mathematics system practice and instruction, and so on.)

Figure 4. Post-Study Scores For Phase IV Corpsmen on Stanford Advanced Form Y (n = 16)

	COMPUTATIONS	CONCEPTS	APPLICATIONS
	5.6	6.9	7.9
	8.8	8.0	6.7
	6.0	6.3	7.7
	7.8	6.0	7.7
	6.0	4.8	7.4
	3.6	3.6	4.7
	8.4	6.6	7.9
	11.7	8.8	9.1
	5.8	6.0	7.7
	7.6	5.4	7.7
	7.8	6.6	7.4
	7.2	6.0	7.7
	7.6	6.0	5.3
	7.2	6.6	4.7
	6.4	6.6	7.9
	5.8	5.7	5.3
Average	7.08	6.24	7.05

4. As would be expected, however, the entry achievement level on the Applications unit in Phase II was still in the mid-fourth grade range. (The existing Mathematics system is almost completely computation-oriented with very little exposure to, or practice on, word problems.) In fact, it is somewhat surprising to note that the Phase IV Corpsmen did have a mid-fifth grade entry level on the Applications unit of the SAT.
5. It will be noted that the Phase II study produced a 1.36-year gain in the Applications unit where it was targeted, while not producing any gain on Computations or Concepts—in fact, small losses. (But at least we are moving closer to the seventh-grade level, being in the mid-sixth grade range.)

   NOTE: It should be remembered that the pre-experiment data in Phase II dates from six months before the study, and thus is not as tidy as the Phase IV data.

6. In Phase IV, we once again observed an entry level to the experimental Word Problems course in the mid-fifth grade range. But this time, with the improvements to the system and materials, we produced substantial achievement gains in all three categories of the Stanford Achievement Tests, and for the first time ended up with the entire group at the sixth-grade level in Concepts and at the seventh-grade level in Computations and Applications. It would seem that we are moving in the right direction. (See Figure 4.)

IV. SUGGESTED ACTION

A. Implications for the existing Mathematics system. As noted previously, the Job Corps Mathematics system does not seem to be working as well as the Reading system.

More significantly, it simply is not producing the desired seventh grade computational skills. (Although this generalization is based on data from only three Centers, bear in mind that the Centers involved in the present study are "older" Centers with a relatively stable and well-trained staff.)

One obvious reason for the disparity between achievement on the Reading and Mathematics systems is the fact that deficiencies in reading are more readily observed by the staff, and perceived by both the Corpsman and the staff as more important to remedy. What seems to be needed is a technique for guaranteeing that a rather fine-grained diagnostic technique is superimposed on the existing Mathematics system, so that the staff can—and in fact will be forced to—focus on the specific mathematics deficiencies of individual Corpsmen.

In the present system, there is a strong possibility that the unit tests are not the most valid possible behavior-measuring instruments. Further, and as noted previously in the final report on Contract No. 953, it is possible for a Corpsman to "test around" the instructional materials by passing the MCP subdiagnostic tests after failing the MKP. This, of course, sets up the possibility that clever Corpsmen can compromise the system by obtaining answers to the MKP and MCP tests.

Finally, and perhaps most important, there is another difference between the Reading and Mathematics systems which may account for better results in reading than in mathematics. In the Reading system, there is a positive "GO-NO GO" check made through a test administered after exposure to the instructional materials and before the Corpsman can be advanced to the next level. In the Mathematics system there is no "level advancement check." That is, a Corpsman can be advanced from level to level by guessing, cheating, lucking his way into, talking his way around, or perhaps simply by repeated test taking, rather than remedial exposure to the instructional materials themselves.

The steps below are recommended as at least partial solutions to the problems of the Mathematics system.

NOTE: It will be apparent that all of the following recommendations involve improving and/or revising staff training. EVCO is currently performing on a Forest Service contract (FS-13-240) that deals with this area. It is suggested that the following recommendations be considered for possible inclusion in the EVCO-developed staff training manual on the Mathematics system.

Step 1. MAKE SURE OF OVERT RESPONSE. In many cases, the effectiveness of the instructional sequences in the existing Mathematics system is being compromised by virtue of Corpsmen skipping over material that they do not understand. It is practically impossible to do any on-the-spot diagnostic and remedial work unless all necessary computations are shown. Statistical data from earlier EVCO research and anecdotal data on the current study both strongly suggest that the Corpsmen be instructed to write every answer in the book, to show necessary calculations, and that this behavior be monitored and enforced by the instructional staff.

Step 2. ENSURE A CONTROLLED (OR PEEK-PROOF) RESPONSE.

The mathematics booklets now in use in the Mathematics system, as originally designed, all require the use of a plastic masking device to conceal the confirmation until after the student has committed himself to a response. While this technique works reasonably well with highly motivated students, it has some drawbacks when used with a target population such as a typical group of Corpsmen. For a variety of reasons (such as wanting to get every answer right, perceiving completion of a mathematics booklet as just another task to be gotten through as rapidly and painlessly as possible, and so on) many Corpsmen will simply copy the correct answer before—and without—performing the necessary thought processes and/or computations. The TMI-Grolier materials were recently modified to an encoded answer format, eliminating the mask. The textbook materials used in this study were in this format. Data obtained in Phase II of this study strongly indicates that there is a sizable decrement in performance when Corpsmen simply copied their way through the program. For example, the textbook-only group achieved only a 4.8 level on the Computations unit while the group that rotated through the machine modes, which more effectively controlled the response, scored at the 5.9 level. Accordingly, we modified this aspect of the experimental design in Phase IV and got five times better achievement (or a full grade-level achievement, i.e., the difference between an achievement gain of 1.30 on the Stanford Applications unit in Phase IV and an achievement gain of only a .26 in Phase II).

It is strongly recommended that the Center mathematics instructors make sure that the Corpsmen are using a masking device of some sort to keep the confirmations covered until they have committed themselves to a response. With the Addison-Wesley materials, this can be done with the vinyl mask provided with the booklets (which, however, have a tendency to get lost). With both the Addison-Wesley books and TMI-Grolier books, a piece of scratch paper will do the job equally well.

Step 3. INVESTIGATE THE APPLICATION OF A CONTROLLED RESPONSE TECHNIQUE. It would be a relatively simple matter to superimpose a system of obtaining controlled responses—at least to selected criterion frames—on the existing Mathematics system. For example, an IBM-type card similar to the one used in the current study could be employed. These cards would provide confirmation to the Corpsman, provide instant feedback to the instructor for on-the-spot tutoring, and could be machine scored for an overall item analysis of the instructional system.

Step 4. OBTAIN MORE PRECISE MEASUREMENT OF MATHEMATICS ACHIEVEMENT LEVEL. At the very least, some technique should be devised guaranteeing that a Corpsman had learned something from his exposure to one of the mathematics units before being processed on to the next. It is strongly suggested that something like the "level advancement check" used in the Reading system should be introduced into the Mathematics system.

As things now stand, Corpsmen can be advanced through the Mathematics system through activities not dissimilar to those found in the typical public school system. This refers to such activities as the use of perhaps invalid measuring instruments, having the tests compromised through having the answers "stolen" and passed around among the Corpsman population, through the whole system's being inadequately and/or carelessly administered (accidental-promotion, as distinct from social-promotion).

Step 5. USE THE STANFORD ACHIEVEMENT TESTS AS EFFECTIVE DIAGNOSTIC INSTRUMENTS. Under the present setup, the Stanford tests are administered early in the Corpsman's Center career, and then apparently dead-filed. They are then administered again upon his completion of the Mathematics system, but there is no apparent advice to the Center staff to use these results in attempting to assess whether the Corpsman has, in fact, learned anything from his exposure to the Mathematics system. As previously indicated, the Corpsmen used in this study had an overall average of mid-fifth grade achievement on the Stanford Computations unit rather than the expected seventh grade level. What is even more distressing—and more susceptible to diagnosis and remediation—is the plight of the 50 percent of those who were below the average. A case that comes to mind is Corpsman No. 14 in the Phase IV study who had an achievement level of 2.6 on the Stanford Computation Unit. Despite the fact that he had been through the Mathematics system, he obviously needed help and the Stanford data was available to pinpoint him and get it for him. But there is presently nothing in the Mathematics system manual which suggests this relatively simple diagnostic technique to the Center instructional staff.

Step 6. **EXPLORE THE USE OF SOME NEW MEASURING INSTRUMENT TO IDENTIFY INDIVIDUALS WHO ARE GOING TO NEED EXTRA HELP, BEFORE ENTERING THEM INTO THE MATHEMATICS SYSTEM.** No matter how good the instructional materials are, and no matter how effectively they are administered, there will still be Corpsmen whose previous learning deficiencies are such that they will need a lot of extra help. Techniques can easily be developed for identifying these individuals; for example, something as simple as standarized IQ measurement. If, however, the Job Corps doesn't choose to get into the IQ business, we might suggest the device we used in the current study, i.e., obtaining the reading level and relating this to the last grade completed in school. While the spread between these two numbers is admittedly a very rough measure of learning disability, we nevertheless considered it better than none at all.

B. Implications for other Instructional Materials now in the Center Curriculum To the extent that it can be determined that ensuring a controlled response is a critical factor in both the learning process and the diagnostic aspects of Conservation Center instruction, this technique should be considered for use with other applicable instructional materials. On our student attitude questionnaire we got uniformly positive responses to the question, "Would you like to take other materials this way?" When the Corpsmen were asked to specify the subjects they would like to take "this way," there were numerous mentions of Reading, World of Work, and Spelling.

Since the EVCO staff originally developed the programed Punctuation course now in use in the Center curriculum, we can predict with some degree of assurance that this course would benefit from the application of controlled response techniques. There are some other possibilities:

1. Develop controlled response techniques to apply to other language-skills instructional materials, such as Spelling (Catalog No. 6011), Punctuation (6012), Writing (6014), and Grammar (6019).
2. Develop controlled response techniques for the "World of Work." These techniques should be especially effective in the Mathematics areas of the World of Work, which are considerably more difficult than the mathematics techniques and skills taught in the existing mathematics system.
3. Consider the development of controlled response techniques to make the graded reading program more effective. As previously mentioned, the level-advancement-checks in the Reading system seem to be relatively effective in guaranteeing expected terminal achievement. (On our measures, for example, they seem to be approximately 70 percent effective compared to a 10 percent figure in the Mathematics system.) It is possible that controlled response techniques superimposed on this system would make it even more effective.

C. Suggestions for Adding Instructional Materials to Center Curriculum

We believe that the Job Corps should consider the adoption of new instructional materials specifically designed to correct deficiencies observed during the course of this study.

As noted previously, the existing mathematics system does not seem to be producing the desired seventh-grade achievement levels. The program used as a test vehicle in this study did produce a seventh-grade level, and thus we feel we would be remiss if we did not suggest its adoption by the Job Corps. It is reasonable to hypothesize that a course of instruction that produced something like a 1.8 year grade-level achievement gain overall—and a 2.5 year gain on the Text-Card Mode—in a two-week period would be a useful addition to the Center curriculum.

Also, we feel it would be profitable to explore applications of the techniques developed in this study to two other major problem areas for Corpsmen, that is, oral and written expression.

D. Possibilities for further Teaching Machine Research The careful reader of this report may by now be wondering what ever became of the teaching machine in this teaching machine study.

Here are the facts:

1. In Phase II, Corpsmen working on two machines and a text performed better than Corpsmen working on only the text.
2. Also in Phase II, Corpsmen rotating among the two machines and the text preferred the machines 9 to 1.
3. In Phase IV, however, when we improved both the materials and the administration of the textbook mode, the Corpsmen on the machines did not achieve as well as the Corpsmen on the text.
4. Also, it should be noted that the Corpsmen who were not working on the machines did not exhibit any interest in doing so. Conversely, one of the Corpsmen on the machine said he would rather work on the text "since the machine didn't give him a chance to review."
5. Also, it is worth noting that three machines and sets of film cartridges were intentionally left at the Grants Center between Phase II and Phase IV to provide "anecdotal-data bait." In other words, we wanted to determine whether the machines would be used by a staff that had seen their instructional effectiveness demonstrated. Although they were not used during this period, the staff continues to indicate that they are planning to use them if they can be retained.

Clearly, there is no compelling data to suggest the widespread adoption of this type of teaching machine in Conservation Centers. Even if only one machine and one program were obtained for experimental use in all the Centers, the required investment would be in the order of magnitude of $27,000.

With all due reporting rigor, however, there does seem to be some motivational effect attributible to the machines.

Since the Mast machines used in this study are government property, it would be relatively inexpensive to conduct further research using these machines and accompanying controlled-response techniques. In this context, the manufacturer of the machines has indicated that a cheaper version will shortly be available that uses a manually operated lever to advance the film, rather than the motorized advance in the present machine. One possibility would be to compare the effectiveness of these two machines on motivation and gain, perhaps with only six students on each version.

One final point should be made. A relatively disappointing performance with this machine, using these materials at this time shouldn't foreclose further research into educational technology by the Job Corps. As has been previously noted, this type of machine functions essentially as a "mechanical page turner" and a relatively small portion of the overall instructional task has been delegated to the machine.

Our staff has recently performed some innovative work on educational systems in which a relatively large portion of the instructional task has been assumed by a closed-circuit television system with computer-mediated diagnostic and prescription techniques. We would be pleased to discuss the potential of these techniques with the Job Corps if and as appropriate.

APPENDIX 1

DATA FROM PHASE II

DATA FROM PHASE II

RESULTS OF STANFORD ACHIEVEMENT TESTS ADMINISTERED SIX MONTHS BEFORE STUDY AND IMMEDIATELY POST-STUDY (n = 20)

	Computations	Concepts	Applications
PRE	5.89	5.44	4.86
POST	5.53	5.36	6.22
GAIN	-.36	-.08	+1.36

POST-EXPERIMENT STANFORD ACHIEVEMENT LEVELS OF TEXT-ONLY AND MIXED-MODE GROUPS

	Computations	Concepts	Applications
Text-Only (n = 5)	4.80	5.82	6.06
Mixed-Mode (n = 28)	5.90	5.66	6.32
	+1.10	-.16	+.26

COMPARISON OF POST-EXPERIMENT ACHIEVEMENT LEVEL OF EXPERIMENTAL GROUP AND A CONTROL GROUP

	Computations	Concepts	Applications
Experimental (n = 33)	5.73	5.68	6.28
Control (n = 31)	5.18	5.46	5.90
	+.55	+.22	+.38

APPENDIX 2

DATA FROM PHASE IV

FIGURE 3. STANFORD ACHIEVEMENT TEST DATA
(Plus Reading-Level Data)

NAME	JOB CORPS READING LEVEL	EVCO-TEST READING LEVEL		LAST SCHOOL GRADE COMPLETED	SPREAD BETWEEN Col 2a & 3	STANFORD ACHIEVEMENT TEST - SCORE ON APPLICATIONS UNIT		STANFORD GAIN (5b - 5a)
		Pre-X	Post-X			Pre-X	Post-X	
	Col 1	Col 2a	Col 2b	Col 3	Col 4	Col 5a	Col 5b	Col 6
GROUP A (Machine)								
1. CLAY	6	X	X	X	X	X	X	X
2. CRAVEN	IVa*	9	12	10	-1	11.1	6.7	-4.4
3. GUARDIOLA	8	3	5	7	-4	6.3	7.4	+1.1
4. MENDOZA	8	2	5	9	-7	6.3	—	—
5. ESTORGA	5	8	7	8	0	5.8	—	—
6. WILLIAMS	8	6	6	10	-4	4.4	—	—
	7.5	5.6	7.0	8.8	-3.2	6.78	7.06	-1.65****
GROUP B (Text)								
7. DAMPIER	7	4	4	9	-5	5.3	7.7	+2.4
8. DIETZ	6	7	5	7	0	5.8	7.7	+1.9
9. HEYMAN	8	7	12	10	-3	6.7	9.1	+2.4
10. LOPEZ	IVa*	12	12	7	+5	8.2	7.4	- .8
11. PALMER	IVa*	9	6	9	0	4.9	4.7	- .2
12. ROMAN	6	7	6	10	-3	5.8	7.9	+2.1
	7.8	7.7	7.5	8.7	-1	6.12	7.42	+1.30
GROUP C (Text-Card)								
13. SINGLETERRY	6	5	5	8	-3	4.4	7.9	+3.5
14. HENRY	IVa+*	4	7	12	-8	5.8	—	—
15. HERNANDEZ	5	3	6	9	-6	7.2	7.9	+ .7
16. HUBBARD	6	4	5	10	-6	4.9	7.7	+2.8***
17. IKERD	5	X	X	X	X	X	X	X
18. GONZALES	8	5	9	7	-2	4.6	7.7	+3.1
	6.7	4.2	6.4	9.2	-5	5.38	7.80	2.52****
Overall Averages	7.33	5.94**	7.00	8.88	-2.94	6.09	7.48	1.22****

* A numerical value of 10 was assumed for averaging purposes.

** Compare 4 to 6.1 average on Phase II experimental group.

*** Took SAT's before completing Unit 15-II, 16, 17, and 18.

**** Not the same as horizontal subtraction of Pre-X and Post-X values, since only SAT completions were used to derive gain figures.

APPENDIX 3
INTERCORRELATION MATRIX

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
JOB CORPS READING LEVEL	1		+.29	+.49	+.30	+.09	+.06	-.09	+.01	-.40	-.46	-.40	+.23	-.04	-.10
EVCO READING LEVEL PRE-X	2	+.29		+.47	-.38	+.19	+.46	+.12	+.52	+.17	-.17	-.28	-.10	*.90	-.33
EVCO READING LEVEL POST-X	3	+.49	+.47		+.40	+.33	+.53	+.11	+.26	-.39	-.14	-.42	+.18	-.34	-.28
EVCO READING LEVEL GAIN	4	+.30	-.38	+.40		+.33	+.18	-.04	-.08	-.49	+.21	+.14	+.32	+.50	-.18
SAT COMPUTATIONS PRE-X	5	+.09	+.19	+.33	+.33		+.66	-.43	+.61	-.00	+.49	+.03	+.02	-.17	*.70
SAT COMPUTATIONS POST-X	6	+.06	+.46	+.53	+.18	+.66		+.27	+.52	+.23	+.27	-.21	-.18	-.51	-.65
SAT COMPUTATIONS GAIN	7	-.09	+.12	+.11	-.04	-.43	+.27		-.06	+.28	-.01	-.03	-.07	-.21	+.29
SAT CONCEPTS POST-X	8	+.01	+.52	+.26	-.08	+.61	+.52	-.06		+.30	+.48	+.15	+.18	-.38	-.30
SAT CONCEPTS GAIN	9	-.40	+.17	-.39	-.49	-.00	+.23	+.28	+.30		+.42	+.43	-.18	-.26	+.03
SAT APPLICATIONS POST-X	10	-.46	-.17	-.14	+.21	+.49	+.27	-.01	+.48	+.42		+.74	-.01	+.14	-.21
SAT APPLICATIONS GAIN	11	-.40	-.28	-.42	+.14	+.03	-.21	-.03	+.15	+.43	+.74		-.11	+.15	-.03
LAST SCHOOL GRADE	12	+.23	-.10	+.18	+.32	+.02	-.18	-.07	+.18	-.18	-.01	-.11		*.56	*.61
LSG-ERL PRE-X (12-2)	13	-.04	*.90	-.34	+.50	-.17	-.51	-.21	-.38	-.26	+.14	+.15	*.56		*.56
LSG-SAT COMP PRE-X (12-5)	14	-.10	-.33	-.28	-.18	*.70	-.65	+.29	-.30	+.03	-.21	-.03	*.61	*.56	

KEY:
PRE-X = PRE-EXPERIMENT
POST-X = POST EXPERIMENT

SAT = STANFORD ACHIEVEMENT TESTS
LSG = LAST SCHOOL GRADE
ERL = EVCO-DETERMINED READING LEVEL

* = SIZE OF CORRELATION DUE IN PART TO NON-INDEPENDENCE OF MEASURES

Appendix 3

CORRELATION DATA

AN ANALYSIS OF THE INTERCORRELATION MATRIX

As a result of the Phase IV study, a number of measures were taken on the Corpsmen participating in the study. These included their Job Corps Reading Level, the Before and After EVCO Reading Levels based on the Ohio Literacy Test, Before and After measures on the Computations, Concepts, and Applications sections of the Stanford Achievement Test, and the last school grade completed. The nature of these scores indicated strongly that a non-parametric measure such as the rank-order correlation coefficient be used, and the values in the table are derived from rank-ordering the scores.

Due to the limited range of scores because of the restricted population with whom we were working (pre-requisite entry levels on both Mathematics and Achievement) and the number of rank-order ties on such things as last school grade completed, it is not surprising that the correlation coefficients tend to be attenuated. However, a perusal of the intercorrelation matrix on the facing page reveals several interesting factors that may shed light on the test instruments, the training procedures, and the population. For example, one of the values of most interest in the present study was the gain between the pre-test and the post-test on the Stanford Achievement Test. Before the experiment, it certainly would have been reasonable to entertain the hypothesis that the better readers would make the greater gains. Such did not prove to be the case. Examination of the intersection of column 11 with rows 1, 2, and 3 shows negative correlation between gain and measured reading level. In other words, the students who did not read as well tended to make relatively greater gains on the application test. With respect to the future use of the Word Problems Program, this is encouraging. Simply stated, it means that the programed material is suited for the poor reader, thus giving the program more generalized application.

It is also interesting to note that the correlation between the Job Corps Reading Level and the EVCO Reading Level became higher after the experiment. See row 1, columns 2 and 3. These figures, coupled with the statistically significant 1.06 year gain in reading as a result of participating in the experiment can perhaps be interpreted this way. By increasing reading level, the experimental procedure tended to spread out the post-test EVCO reading scores, from which it is reasonable to assume that a higher correlation with the Job Corps Reading Level would be obtained, as indeed it was. Said another way, a homogeneous group with a lower reading level will not produce scores which will correlate as highly as will the same group when they have become more heterogeneous in their reading ability as a function of training.

Now compare the various pre- and post-tests on Computations, Concepts, and Applications of the SAT. As might reasonably be expected, these tend to be positively correlated, ranging from +.27 to +.66. The only interpretation that needs to be made here is that this indicates reliability in the testing instrument, since it is reasonable to assume that student mathematical ability in computations, concepts, and applications will tend to intercorrelate positively.

A word of explanation on columns 13 and 14 is in order. The attempt here was to observe and analyze any correlation between any of the other measures of achievement and these two rough measures of learning disability. To obtain the values for columns 13 and 14, we simply subtracted the pre-experiment reading and mathematics grade levels from the last school grade completed for each Corpsman. (For example, if a Corpsman had graduated from the 12th grade but tested at the 5th grade on reading and the 3rd grade on mathematics, we took his absolute reading disability to be 7 and his mathematics disability to be 9.)

Correlating these two values with Stanford Application gains — the target objective of the Word Problems Program — we see a low positive correlation of +.15 and a low negative correlation of -.03, respectively. Accordingly, it seems tentatively reasonable to hypothesize that the course will produce Applications gains independently of previous learning disabilities.